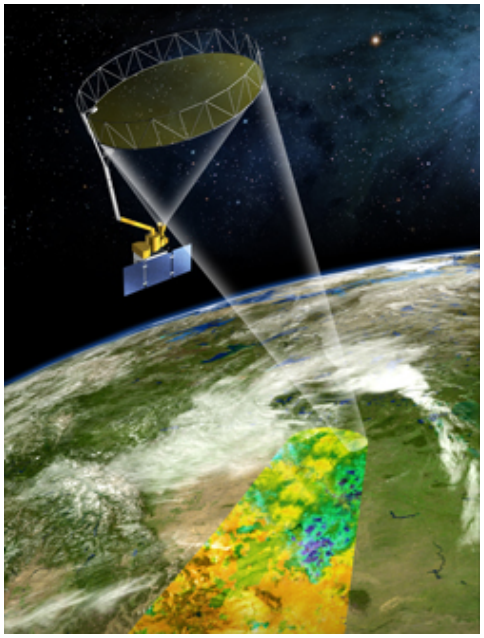
National Aeronautics and Space Administration
Goddard Space Flight Center, Greenbelt, MD

Soil Moisture Active Passive (SMAP) Mission Applications Plan



Edited by:

Molly Brown[1], Susan Moran[2], Vanessa Escobar[3], Dara Entekhabi[4]

[1]SMAP Applications Coordinator, [2]SMAP Applications Working Group Chair, [3]Deputy SMAP Applications Coordinator, [4]SMAP Science Definition Team Leader

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1. Introduction

In pursuing answers to fundamental science questions about the Earth system, many important results are achieved that can be of near-term use and benefit to society. The overarching purpose of the NASA Applied Sciences Program is to discover and demonstrate innovative uses and practical benefits of NASA Earth science data, scientific knowledge, and technology. Here we seek to engage the science data use community early in the Soil Moisture Active Passive (SMAP) mission design and development process allowing for better preparation for eventual data delivery, and to develop rapid and useful response products. The focus of this activity is to demonstrate the value of SMAP products to operational users.

2. Goals

The overall goal of the SMAP Applications program is to engage SMAP end users and build broad support for SMAP applications through a transparent and inclusive process. SMAP is one of four first-tier missions recommended in the Decadal Survey report of the National Research Council's Committee on Earth Science and Applications from Space (Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond, Space Studies Board, National Academies Press, 2007). SMAP data have both high science value and high applications value. The accuracy, resolution, and global coverage of SMAP soil moisture and freeze/thaw measurements are invaluable across many science and applications disciplines including hydrology, climate, carbon cycle, and the meteorological, environmental and ecology applications communities.

The Decadal Survey report states that "...addressing the environmental challenges will not be possible without increased collaboration between Earth scientists and researchers in other disciplines including the social, behavioral, and economic sciences and policy experts. It is necessary now to build on the paradigm of Earth system science and strengthen its dual role of science and applications. This duality has always been an element of Earth science, but it must be leveraged more effectively than in the past..."_ (Chapter 1: Earth Science: Scientific Discovery and Societal Applications).

The sub-goals of the SMAP Applications program are to:

- Establish a SMAP Applications Working Group (AppWG) and develop a SMAP Applications Plan (this document);
- Promote the use of SMAP products to a community of end-users and decision makers that understand SMAP capabilities and are interested in using SMAP products in their application;
- Facilitate feedback between SMAP user communities through the SMAP Applications Working Group and the SMAP mission;
- Provide information on and documentation of collaboration with different classes of users and communities and design communication strategies to reach out to

these new communities, including those of precipitation, drought detection, agriculture, and ecosystem modeling, among others;

- Guide new users using resources and SMAP experts and associated personnel to assist with integration of data into their processes and systems;
- Foster and facilitate relationships between mission Early Adopter research and the SMAP SDT and report back to the mission on:
  - how SMAP data will be used by thematic communities after launch;
  - challenges identified with data resolution, ingestion, processing, and access;
- Coordinate with SMAP Education and Public Outreach (EPO) personnel and the media to publicize SMAP products, users and objectives to help improve the visibility of the mission with scientists and scientific communities.

The SMAP Applications program is guided by a SMAP Applications Team which includes members of the SMAP Science Definition Team, the SMAP Project, and NASA Headquarters (see Acknowledgments section).

The SMAP Applications Plan is a living document that will be updated continuously as the SMAP mission proceeds through its development and operational phases.

3. SMAP Mission Description

The Soil Moisture Active Passive (SMAP) mission includes the SMAP observatory (spacecraft and instrument), the Project and Program, and the Science Definition Team (SDT) selected by NASA to guide the science aspects of the mission.

The SMAP observatory will be launched in the 2014-2015 time frame to provide global measurements of soil moisture and freeze/thaw state. These measurements will be used to enhance understanding of processes that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models. SMAP science measurements will enable applications including drought and flood guidance, agricultural productivity estimation, weather forecasting, climate predictions, disease risk assessment and national security.

The SMAP science data products are listed in Table 1. Applications using SMAP data will require data with resolutions that are similar to datasets currently in use. SMAP radar measurements have a spatial resolution of 1-3 km over the outer 70% of the swath. The high resolution of the radar is critical for accurate determination of freeze/thaw state (L3_FT_A product) in the heterogeneous landscapes of the boreal forest region north of 45N latitude. The 40-km soil moisture product (L2_SM_P) is derived from the radiometer measurements. The radar and radiometer measurements are combined to generate an intermediate resolution 10-km product (L2_SM_AP) that optimizes the resolution and accuracy attributes of the radar and radiometer. The radar and radiometer measurements will also be merged with process-based numerical models of land surface energy, water, and carbon dynamics to provide spatially and temporally complete global estimates of root zone soil moisture (L4_SM) as well as estimates of carbon source/sink activity (net ecosystem exchange; L4_C).

Table 1. SMAP Science Data Products

Product	Description	Gridding (Resolution)	Latency*	
L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_Radar	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer T_B in Time-Order	(36x47 km)	12 hrs	
L1B_S0_LoRes	Low Resolution Radar σ_o in Time-Order	(5x30 km)	12 hrs	
L1C_S0_HiRes	High Resolution Radar σ_o in Half-Orbits	1 km (1-3 km)**	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L2_SM_A	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
L2_SM_P	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L3_FT_A	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	
L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

* The SMAP project will make a best effort to reduce the data latencies beyond those shown in this table.
** Over the outer 70% of the swath.

3.1 Availability of Data Products

The SMAP mission will make science data products available to the public through a NASA-designated Earth science data center[1]. SMAP will coordinate the release of data product versions with the data center and will ensure the completeness and accuracy of quality control information and validation status of the data products. There will be a calibration and validation (Cal/Val) phase during the science mission that will follow the 90-day post launch initial orbit checkout (IOC) phase. The duration of the Cal/Val phase is 6 months for Level 1 products and 12 months for Level 2 and higher products.

Latency is defined as the average time under normal operating conditions between data acquisition by the SMAP observatory and delivery of the data to the data center. If feasible, agencies with need for shorter data latencies than shown in Table 1 should negotiate special data access arrangements (and potential cost-sharing) with NASA and the SMAP Project.

[1] SMAP Level 1 radar data products will be made available through the Alaska Satellite Facility (ASF) in Fairbanks, Alaska. All other data products in Table 1 will be made available through the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado.

4. Strategic Partners

To gain the support and acceptance of SMAP products by Federal agencies that are strong users of satellite remote sensing, the SMAP mission will form strategic alliances with key organizations within the Department of Defense (DoD), US Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA), the Department of Interior (DoI) and the US Geological Survey (USGS). The SMAP Applications Working Group (AppWG) will identify potential models, programs and processes that would benefit from SMAP data in these agencies and develop partnerships to amend or improve these processes in preparation for the eventual availability of the data. State governments, non-governmental organizations and the private sector can also benefit from these initial investments in the federal sector and can further be benefited through the future solicitations and working group activities. By being strategic as to where our efforts will be focused before launch, and ensuring that the positive results are publicized in peer-reviewed literature as well as online in newsletters and list-serves, the SMAP mission will be able to maximize its impact.

4.1 International Partnerships and Coordination

The SMAP mission is developing ongoing relationships with a broad array of international organizations, particularly with international scientific organizations involved with global monitoring and modeling. The Group on Earth Observations (GEO)[2] is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS[3]. The Integrated Global Observing Strategy Partnership (IGOS-P)[4] has established the Global Water Cycle theme. The overall objective of the Integrated Global Water Cycle Observations (IGWCO) is to develop and promote strategies for the coordination of diverse global water cycle observing systems, and to make progress towards an integrated water cycle observation system that unites data from different sources (e.g. satellite systems, in-situ networks, field experiments, and new data platforms) with emerging data assimilation and modeling capabilities. The International Soil Moisture Working Group (ISMWG) was established in 2005 to handle the main objectives of this IGWCO water cycle variable. Through these international coordination committees a wide variety of national and international organizations can have access to SMAP information and data, engage with the applications activities, learn about ways SMAP data can be ingested into processes and models, and assist with the development of climate data records and other useful products.

4.2 NASA Programmatic Relationships

Earth science at NASA is conducted within the Science Mission Directorate (SMD). SMD conducts a program of breakthrough research to advance fundamental knowledge on the most important scientific questions about the global integrated Earth system. The research encompasses:

- the global atmosphere;

[2] http://www.earthobservations.org/

[3] http://www.earthobservations.org/geoss.shtml

[4] http://www.eohandbook.com/igosp/Water.htm

- the global oceans including sea ice;
- land surfaces including snow and ice;
- ecosystems; and
- interactions among the atmosphere, oceans, land and ecosystems, including humans.

NASA relies on the science community to identify and prioritize leading-edge scientific questions and the observations required to answer them. SMAP is one of the missions identified as a priority for NASA's Science Mission Directorate through the most recent decadal survey.

4.3 Role of NASA's Application Program

The broader NASA Applied Sciences Program works with other government agencies, universities, and non-profit, international, and private sector organizations to extend the benefits of Earth Science research results. This community of people and organizations includes those who provide Earth science results and those who utilize those results in their decision-making activities. NASA works with organizations that have the right tools to apply NASA results from Earth science research to meet societal needs. Examples include helping manage forest fires, coastal environments, agriculture, impacts of infectious diseases, aviation safety, risks to public health and hurricane forecasting. The SMAP Applications Program is a mission-funded program that works in coordination with the NASA Applied sciences program.

5. SMAP Applications Working Group

The SMAP Applications Working Group (AppWG) is an inclusive group that accepts members through registration on the SMAP website at http://smap.jpl.nasa.gov/science/wgroups/applicWG and through networking and invitation. Two key roles for members of the SMAP AppWG are: (1) SMAP application development, and (2) feedback to the SMAP mission. The AppWG can achieve these goals through partnering with SMAP Science Definition Team (SDT) members and communicating with the SMAP Applications Coordinator (http://smap.jpl.nasa.gov/science/team). The objectives of the AppWG are to:

- assess current applications benefits and requirements for SMAP products;
- develop a community of end-users that understand SMAP capabilities and are interested in using SMAP products in their application;
- foster Early Adopters who can work with the SMAP project during the pre-launch period, particularly to assess impacts on their applications;
- provide information about SMAP and its products to the broad user and science community;
- provide guidance to future solicitation processes.

Two main user groups in the SMAP AppWG are defined and categorized by their use of SMAP data in their operations and activities. These are:

- **Community of Practice** - users who will partner to optimize their use of SMAP products, possibly even before launch as part of the SMAP testbed activities and SMAP calibration/validation; and
- **Community of Potential** - users that are unfamiliar with SMAP capabilities but have the potential to benefit from SMAP products in their application.

5.1 Interactions between the AppWG and the SMAP Mission

The SMAP mission will provide the AppWG with the following:

1. Open access to planned SMAP data products via a designated NASA Earth science data center:
2. Access to instrument and geophysical retrieval products with moderate latencies of 12 and 24 hours (the SMAP project will make a best effort to further reduce these latencies):
3. Access where possible to simulated SMAP data products generated pre-launch by algorithm and observing system simulation experiments conducted on the SMAP Science Data System (SDS) Testbed:
4. Collaborative use of the SMAP SDS Testbed to develop value-added products in the simulation environment for general distribution:
5. Notifications of NASA Applied Sciences Program (ASP) solicitations with potential opportunities for SMAP product application; and
6. Opportunities for user feedback to the science team to improve or adjust deficiencies in retrieval or data product algorithms

In turn, the SMAP AppWG will assist the SMAP mission in conducting the preliminary scientific research required to promote the use of SMAP data products in previously identified applications and demonstrate the potential use of SMAP in new applications. This research should be conducted with the goal of refining our current understanding of science and application requirements for SMAP data products and feeding this information back to the SMAP mission via the SMAP AppWG.

Special data or assistance requests beyond the opportunities listed above should be submitted as a white paper on the SMAP application that would include: (1) application description; (2) data currently used in application; (3) desired SMAP data product(s); (4) key people involved; (5) ancillary data needs; (6) requested simulated data products and/or field experiment demonstration; (7) potential implementation strategy; (8) next steps (deadlines/timelines); (9) how to integrate into future projects; and (10) product output format. This would assist the SMAP mission in determining the magnitude of the effort required and the return on staff investment.

6. Implementation Strategy

The user engagement strategy will follow a pathway from simple knowledge of the SMAP data configuration and availability to actively using the data in the user system or

process. Figure 1 shows the general strategy for engagement of users. Users will learn about the SMAP mission in a variety of ways, including those listed in the next section. Users will be ready to use SMAP data when they engage in analysis and demonstration, and have an understanding of the impact of the data on their own processes. It is not expected that all users will achieve readiness to integrate SMAP data, but those that do will be powerful examples for others to follow. In the pre-launch phase when only testbed simulations of soil moisture datasets are available, the SMAP mission expects to work with user organizations to move as far along as possible in the cycle of engagement. Through this work we expect to find additional organizations and communities who may be interested in SMAP data.

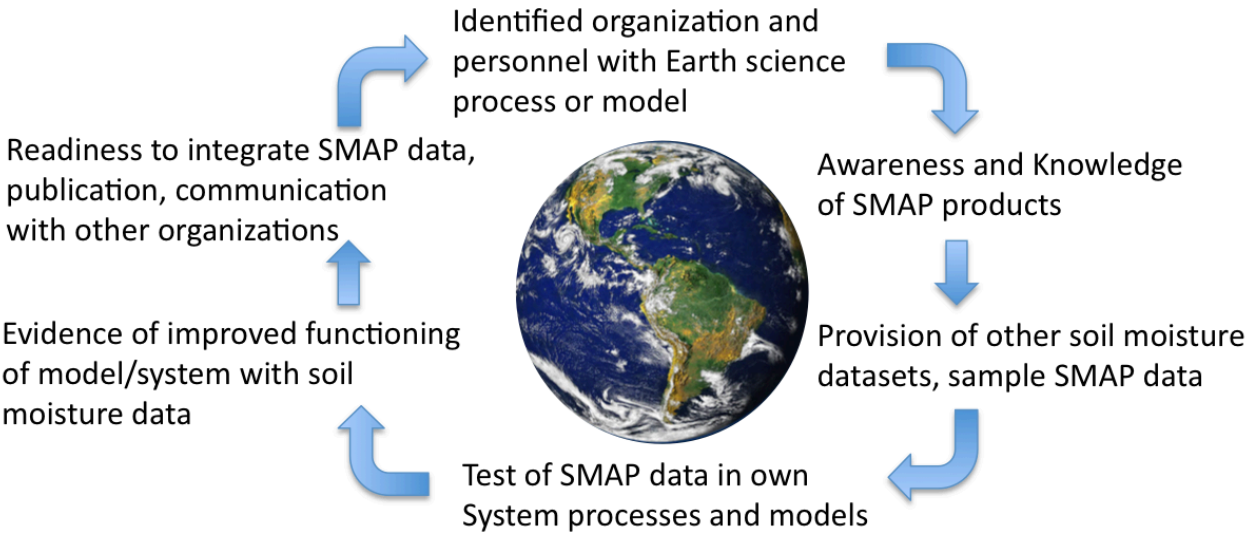

Figure 1. Flow of engagement of users from passive awareness to actively using SMAP data once it becomes available.

To facilitate implementation of these steps, the SMAP mission has appointed a SMAP Applications Coordinator to serve as a liaison between the SMAP mission and the SMAP AppWG. The coordinator will engage with agencies to define data attributes that would best facilitate the entrainment of SMAP data products within operational frameworks. We envision that this relationship with relevant agencies will foster case-examples and demonstrations of the operational uses of SMAP data sets. The coordinator will also work with SMAP scientists to refine mission data products in order to best meet application needs.

6.1 Engagement with Early Adopters

The SMAP Early Adopter program promotes applications research to provide a fundamental understanding of how SMAP data products can be scaled and integrated into organizations' policy, business and management activities to improve decision-

making efforts. SMAP Early Adopters are defined as those groups and individuals who have a direct or clearly defined need for SMAP-like soil moisture or freeze/thaw data, and who are planning to apply their own resources (funding, personnel, facilities, etc) to demonstrate the utility of SMAP data for their particular system or model. The goal of this designation is to accelerate the use of SMAP products after launch of the satellite by providing specific support to Early Adopters who commit to engage in pre-launch research that would enable integration of SMAP data in their applications.

Early Adopters agree to:

1. Engage in pre-launch research that will enable integration of SMAP data after launch in their application:
2. Complete the project with quantitative metrics prior to launch:
3. Join the SMAP Applications Team to participate in discussions of SMAP data products related to application needs:
4. Participate in the implementation of the SMAP Applications Plan by taking lead roles in SMAP applications research, meetings, workshops, and related activities; and

The SMAP Project agrees to:

1. Incorporate the Early Adopter contributions into the SMAP Applications Plan:
2. Provide Early Adopters with simulated SMAP data products: and
3. Provide Early Adopters with planned pre-launch calibration and validation (cal/val) data from SMAP field campaigns, modeling, and synergistic studies

6.2 Identification and Promotion of Community of Potential

Through a series of pre-launch contacts and workshops, likely and potential SMAP applications have been identified (Table 2) and are detailed in the first SMAP applications workshop report[5]. For each of these applications, there is a distinct and active science community that is working on improving methods and ingesting satellite remote sensing from a variety of sensors. The SMAP Applications Plan will focus on targeting more international efforts and promoting “potential” applications to the list of “likely” applications.

6.3 SMAP Applications Research

As available resources allow, a SMAP Applications Scientist may be appointed to run models, design experiments, and study impacts of SMAP data products. This research would be specific to SMAP data and its data attributes, and would add to published literature 'data-denial' experiments based on more general cases. The SMAP AppWG is encouraged to conduct SMAP-specific applications research as described in previous sections.

[5] http://smap.jpl.nasa.gov/files/smap2/Workshop_Report_100309_final.pdf

6.4 Coordination with SMAP Calibration and Validation

The AppWG will play a role in the design of SMAP calibration and validation (Cal/Val) activities. Tasks will include guiding the selection of field campaign sites and providing applications-related input to the design of field campaigns. In doing so, the AppWG should attempt to maximize the relevance of Cal/Val activities for particular applications. The AppWG can also provide a forum for publicizing planned field campaigns and attracting more involvement from groups interested in SMAP applications.

Table 2. SMAP Applications identified at the 1st SMAP Applications Workshop

Area	Likely Mission Applications	Potential Mission Applications
Weather	More accurate weather forecasts; prediction of severe rainfall	Regional weather prediction improvements
Natural Disasters	Drought early warning decision support; key variable in floods and landslides; operational flood forecast; lake and river ice breakup; desertification	Fire susceptibility; global flood mapping; heat-wave forecasting
Climate Variability and Change	Extended climate prediction capability; linkages between terrestrial water, energy, and carbon cycles; land / atmosphere fluxes and carbon (CO_2) source/sink activity for atmospheric greenhouse gasses	Long term risk assessments
Agriculture and Forestry	Predictions of agricultural productivity; famine early warning; Monitoring agricultural drought	Crop management at the farm scale; Input to fuel loading models
Human Health	Landscape epidemiology; heat stress and drought monitoring; insect infestation; emergency response plans	Disease forecasting and risk mitigation
Ecology	Carbon source/sink monitoring; ecosystems forecasts; improvements in monitoring vegetation and water relationships over land	Wetlands resources and bird migration monitoring; cap-and-trade carbon inventory assessment and monitoring
Water Resources	Regional and local water balance; more effective management;	Variability of water stored in lakes, reservoirs, wetlands and river channels monitoring
Ocean Resources	Sea-ice mapping for navigation, especially in coastal zones; temporal changes in ocean salinity	Provision of ocean wind speed and direction, related to hurricane monitoring
Insurance Sector	More accurate weather forecasts; prediction of severe rainfall; operational severe weather forecasts; mobility and visibility	Crop insurance programs; flood insurance programs; tourism and recreation
Coastal Inundation	Input to sea level rise products	Maps of coastal inundation; Monitoring ocean winds for hurricane monitoring
Drought	Early warning decision support; drought monitor products	Desertification identification
Flood	Improved forecasts, especially in medium to large watersheds; flood mapping; protection of downstream resources; soil infiltration conditions; prediction of ice breakup	Prediction of the impact of tropical storms on hydrology
Ecosystem Health	Improvements in monitoring of vegetation health and change; ecosystem dynamics	Wetlands and bird migration monitoring; Rangeland forage productivity forecasts
Wildfires	Input into fire potential models	Improvements in fuel loading models, especially for non-heavily forested areas

6.5 Coordination with other Decadal Survey Missions

The NRC Decadal Survey recommended 15 new space missions for NASA (including one joint mission with NOAA) and three missions for NOAA (including the one joint mission). A goal of the SMAP Applications Plan is to coordinate SMAP applications with other planned NASA and NOAA Decadal Survey Missions. (http://www.nap.edu/catalog.php?record_id=11820).

7. Communication and Engagement Strategies

The SMAP AppWG will function as a SMAP Community of Support. Outreach activities to science, government, educational, and layperson communities will be coordinated with the activities of the SMAP Applications program, to ensure a clear path for interested users from first contact to Early Adopter, and then maintain relationships after launch.

A broad program is planned to engage and maintain continuity with users including:

- Regular AppWG workshops that will include participants from all possible users in each community, as well as smaller disciplinary events hosted at other meetings or sites as the opportunities arise. These meetings and events will be subdivided into three categories based on the focus and objectives of the meetings, as follows:

    1. **SMAP Applications Workshops**: provide an update of the mission and its progress to the community of interest and are set up to exchange information about SMAP soil moisture and freeze/thaw state products on a broad scale. Workshops are organized annually or every two years and provide feedback to the SMAP mission about SMAP product applications.

    2. **SMAP Applications Focus Sessions:** provide a forum for a user group to receive specific support and information on the utility of SMAP soil moisture and freeze-thaw state products for thematic mission objectives. Focus sessions are concentrated one-day events focused on a thematic community. The community organizes the event and SMAP mission personnel participate.

    3. **NASA Applications Tutorials:** are organized to discuss products and applications of multiple NASA decadal missions. Tutorials combine mission product application opportunities and leverage innovation for how to best combine data sets. Tutorials are hosted by an end user group such as USDA or USGS but are organized and managed by the decadal mission or the SMAP Applications Team.

- SMAP science and applications organized sessions, papers and posters in widely attended remote sensing and environmental scientific meetings. These include, but are not limited to:

    - American Geophysical Union Fall (AGU)
    - Association of American Geographers (AAG)

- Ecological Society of America (ESA)
- International Symposium on Remote Sensing of Environment (ISRSE)
- African Association of Remote Sensing of the Environment (AARSE)
- International Geoscience and Remote Sensing Symposium (IGARSS)
- Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment (MicroRad)
- American Meteorological Association (AMS)
- American Association for the Advancement of Science (AAAS)
- SPIE Conference: Security and Defense
- The International Emergency Management Society (TIEMS)

- Submit content in the form of articles, announcements or descriptions of the mission in newsletters, user forums, or other venues frequented by the user community. This includes newsletters such as:
  - BARC e-Update http://www.ars.usda.gov/News/docs.htm?docid=8132
  - EOS Transactions http://www.agu.org/pubs/eos-news/supplements/
  - Montana Water Newsletter http://water.montana.edu/mwnewsletter/default.asp
  - GEWEX News http://www.gewex.org/gewex_nwsltr.html
  - Flood Risk Management Newsletter (USACE) http://operations.usace.army.mil/Flood/pdfs/FRM-0903.pdf
  - Western Governors' Association News http://www.westgov.org/index.php?option=com_wga&view=news&Itemid=55
  - Western Federal Agency Support Team (WestFAST) newsletter http://www.westgov.org/wswc/WestFAST/newsletter%20ap%202010.pdf

- The SMAP Applications web page [http://smap.jpl.nasa.gov/applications/] will integrate and highlight all the ongoing activities from the applications programs, and will include articles, presentations and posters from meetings and planning documents. It will be routinely updated and provide a comprehensive overview of applications and potential methods of incorporating SMAP data. The website will have clear contact information and provide ways to get data, organize new projects and receive information materials for each application area listed above about what has already been done and what is effective.

- The SMAP mission will target key international user groups that are mature, have solid missions and budgets, and can ensure that investments are made in new ways of using soil moisture information. These groups include the United Nations Food and Agriculture Organization (FAO), the European Union (EU) Joint Research Council (JRC), the USDA Foreign Agriculture Service (FAS), the US Agency for International Development (USAID), the US Air Force Weather Agency, and others.

- The SMAP mission will write a "Lessons Learned" report on the SMAP Application efforts. This report will capture feedback from users and Early Adopters as well as describe how user feedback was implemented by the SMAP mission prior to launch. This report will serve as a historical document for the mission as well as a template for other mission Application programs.

8. Performance

The overall goal of this plan is to engage SMAP end users and build broad support for SMAP applications. Because SMAP is the first NASA Earth Science decadal mission to be flown, a process will be initiated whereby the SMAP applications program explores the best ways to assess interaction and integration of SMAP data with the user community. The development of a functioning group of Early Adopters should produce quantitative metrics related to long-term projects, milestone completion, and movement of SMAP products into routine operations. The regular AppWG workshops should provide inclusive and transparent oversight of SMAP Applications Plan implementation as well as plan revisions.

The SMAP mission will create a 'lessons learned' document at each stage of the mission, describing how metrics might be developed to capture the activities of the SMAP applications program. Through the work of the SMAP Applications Team, a pilot project will be developed that can provide guidance for future NASA decadal missions, including appropriate metrics, impacts, and valuations of the success of the program.

9. Acknowledgments

The SMAP Applications Team is comprised of Molly Brown and Vanessa Escobar (SMAP Applications Coordinators), Susan Moran (SMAP Applications Working Group Chair), Dara Entekhabi (SMAP Science Definition Team Leader), Eni Njoku (SMAP Project Scientist), Peggy O'Neill (SMAP Deputy Project Scientist), Kent Kellogg (SMAP Project Manager), Brad Doorn (NASA Headquarters Applied Sciences Program Manager), and Jared Entin (NASA Headquarters Program Scientist).

10. List of Acronyms

AFWA	U.S. Air Force Weather Agency
AppWG	Applications Working Group
Cal/Val	Calibration and Validation
DoD	Department of Defense
DoI	Department of Interior
EA	Early Adopter
EPO	Education and Public Outreach
EU	European Union
FAO	Food and Agriculture Organization
FAS	USDA Foreign Agriculture Service
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems

IGOS-P	Integrated Global Observing Strategy Partnership
IGWCO	Integrated Global Water Cycle Observations
IOC	In-Orbit Checkout
ISMWG	International Soil Moisture Working Group
JRC	Joint Research Council
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
SDT	Science Definition Team
SMAP	Soil Moisture Active Passive
SMD	Science Mission Directorate
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey